CLAIMS

What is claimed is:

1. A method for processing a measured signal to extract a signal component and suppress a noise component of the measured signal, wherein the signal component is a substantially periodic signal characterized by a substantially well-defined peak-to-peak intensity value, the method comprising the steps of:

(i) determining upper and lower envelopes of the measured signal; and

(ii) analyzing the upper and lower envelope values to extract the signal component from the measured signal.

2. The method, as set forth in claim 1, wherein the step analyzing the upper and lower envelope values includes the step of determining a median of the difference between the upper and lower envelope values, as an alternating value in the signal component.

3. The method, as set forth in claim 1, wherein the step of analyzing the upper and lower envelope values includes the step of determining a median of the upper envelope values, as a constant value in the signal component.

4. The method, as set forth in claim 1, wherein the step of analyzing the upper and lower envelope values includes the step of determining a median of the half of the sum of the upper and lower envelope values, as a constant value in the signal component.

5. The method, as set forth in claim 1, wherein the measured signal is a physiological signal.

6. The method, as set forth in claim 5, wherein the signal component is pulsatile blood-related signal.

7. The method, as set forth in claim 6, wherein the pulsatile blood-related signal is indicative of oxyhemoglobin saturation level.

8. The method, as set forth in claim 7, wherein the step of analyzing the upper and lower envelope values includes the step of determining a median of the difference between the upper and lower envelope values as an AC component of the pulsatile blood-related signal, and determining a median of the upper envelope values as a DC component of the pulsatile blood-related signal.

9. The method, as set forth in claim 7, wherein the step of analyzing the upper and lower envelope values includes the step of determining a median of the difference between the upper and lower envelope values as an AC component of the pulsatile blood-related signal, and determining a median of a half of the sum of the upper and lower envelope values as a DC component of the pulsatile blood-related signal.

10. The method, as set forth in claim 1, wherein the measured signal is a response of a sample to the application of an external field.

11. The method, as set forth in claim 10, wherein the measured signal is a light response of the sample to incident light.

12. The method, as set forth in claim 10, wherein the sample is biological.

13. The method, as set forth in claim 1, for use with a measurement device for non-invasive measurements of patient's blood and heart conditions, the signal component being a pulsatile blood-related signal and containing a signal component characterized by a specific asymmetric shape, the method further comprising the steps of:

- defining a kernel function being a derivative of a Gaussian with parameters matching the characteristics of the signal component with the asymmetric shape; and

- applying spectral filtering to the measured signal with the kernel function, thereby enhancing the signal component characterized by the specific asymmetric shape relative to a noise component in the filtered signal, to thereby enable further processing of the enhanced pulse signal to determine the heart rate.

14. The method, as set forth in claim 13, wherein the step of analyzing the upper and lower envelope values includes the steps of determining a median of the difference between the upper and lower envelope values of the measured signal as an AC component of the pulsatile blood-related signal component, and determining a median of the upper envelope values as a DC component of the pulsatile blood-related signal component.

15. The method, as set forth in claim 13, wherein the step of analyzing the upper and lower envelope values includes the steps of determining a median of the difference between the upper and lower envelope values of the measured signal as an AC component of the pulsatile blood-related signal component, and determining a median of a half of the sum of the upper and lower envelope values as a DC component of the pulsatile blood-related signal component.

16. A signal processing method for use in determination of a desired parameter of a sample, the method comprising the steps of:

- providing a measured signal representative of a response of the sample to an external field, the measured signal comprising a signal component indicative of the desired parameter, and a noise component, the signal component being a substantially periodic signal characterized by a substantially well-defined peak-to-peak intensity value;
- determining upper and lower envelopes of the measured signal; and
- analyzing the upper and lower envelope values to extract the signal component from the measured signal, to enable further processing of the extracted signal component to determine the desired parameter.

17. The method, as set forth in claim 16, wherein the step of providing the measured signal includes the step of sampling and frequency filtering of the response.

18. A method for processing a measured signal to enhance a signal component relative to a noise component in the measured signal, wherein the signal component is a characterized by a specific asymmetric shape, the method comprising the steps of:

- defining a kernel function being a derivative of a Gaussian with parameters matching the characteristics of the signal component; and
- applying spectral filtering to the measured signal with the kernel function, thereby enhancing the signal component relative to the noise component in the filtered measured signal.

19. A method for processing a measured signal including a first signal component in the form of a substantially periodic signal with substantially well-defined peak-to-peak intensity value, and a second signal component characterized by a specific asymmetric shape, to extract the signal components from noise components, the method comprising the steps of:

- processing the measured signal by determining upper and lower envelopes thereof, and analyzing the upper and lower envelope values to extract the first signal component; and

- defining a kernel function being a derivative of a Gaussian with parameters matching characteristics of the second signal component, and processing the measured signal by filtering it with the kernel function parameters, thereby enhancing the second signal component relative to the noise component in the filtered measured signal.

20. A method for processing measured data representative of a first measured signal including a first signal component in the form of a substantially periodic signal with substantially well-defined peak-to-peak intensity value, and a second measured signal including a second signal component characterized by a specific asymmetric shape, to extract the signal components from noise components, the method comprising the steps of:

- processing the first measured signal by determining upper and lower envelopes thereof, and analyzing the upper and lower envelope values to extract the first signal component;

- defining a kernel function being a derivative of a Gaussian with parameters matching characteristics of the second signal component, and processing the second measured signal by filtering it with the kernel function parameters, thereby enhancing the second signal component relative to the noise component in the filtered second measured signal.

21. The method, as set forth in claim 20, wherein the first signal component is a pulsatile blood-related signal.

22. The method, as set forth in claim 20, wherein said second measured signal is ECG, the second signal component being representative of a QRS segment in the ECG signal.

23. A control unit for use with a measurement device to receive and process a measured signal generated by the measurement device so as to extract a signal component from a noise component in the measured signal, the signal component being a substantially periodic signal with substantially well-define peak-to-peak intensity value, the control unit comprising a data processing and analyzing utility preprogrammed to determine upper and lower envelopes of the measured signal, and analyzing the upper and lower envelope values to extract the signal component.

24. A control unit for use with a measurement device to receive and process a measured signal generated by the measurement device so as to enhance a signal component relative to a noise component in the measured signal, the signal component being characterized by a specific asymmetric shape, the control unit comprising a data

processing and analyzing utility preprogrammed to define a kernel function being a derivative of a Gaussian with parameters matching the characteristics of the signal component, and apply spectral filtering to said measured signal with the kernel function parameters, thereby enhancing the signal component relative to the noise component in the filtered measured signal.

25. A pulse oximeter comprising:

(a) a measurement device operable to illuminate a measurement location with incident light of predetermined frequencies, detect a light response of the measurement location to said incident light, and generate a measured signal indicative thereof including a signal component representative of a pulsatile blood-related signal; and

(b) a control unit connectable to the measurement device for receiving and processing the measured signal, the control unit comprising a data processing and analyzing utility preprogrammed to determine upper and lower envelopes of the measured signal, and analyze the upper and lower envelope values to extract said pulsatile blood-related signal component from a noise component in the measured signal.

26. The pulse oximeter, as set forth in claim 25, wherein the analyzing of the upper and lower envelope values comprises determining a median of the difference between the upper and lower envelope values as an AC component of the pulsatile blood-related signal, and determining a median of the upper envelope values as a DC component of the pulsatile blood-related signal.

27. The pulse oximeter, as set forth in claim 25, wherein the analyzing of the upper and lower envelope values comprises determining a median of the difference between the upper and lower envelope values as an AC component of the pulsatile blood-related signal, and determining a median of a half of the sum of the upper and lower envelope values as a DC component of the pulsatile blood-related signal component.

28. The pulse oximeter, as set forth in claim 25, for determining a patient's heart rate, the measured signal comprising a blood-related signal component characterized by a specific asymmetric shape, the control unit being preprogrammed to process the measured signal by filtering it with a predefined kernel function being a derivative of a Gaussian with parameters matching the characteristics of said signal component, thereby enhancing said signal component characterized by the specific asymmetric shape relative to a noise component in the filtered measured signal.

29. A measurement system to be applied to a sample to determine a desired parameter thereof, the system comprising:

- a measurement device operable to apply an external field to a measurement location on the sample or medium, detect a response of the measurement location to the application of the external field, and generate measured data indicative thereof, the measured data containing a first measured signal including a signal component in the form of a substantially periodic signal with a substantially well-defined peal-to-peak intensity value, and a second measured signal including a second signal component characterized by a specific asymmetric shape; and

- a control unit connectable to the measurement device for receiving and processing the measured data, the control unit comprising data processing and analyzing preprogrammed to process the first measured signal by determining upper and lower envelopes thereof and analyze the upper and lower envelope values to extract the first signal component from a noise component in the first measured signal, and to process the second measured signal by filtering it with a predefined kernel function being a derivative of a Gaussian with parameters matching the characteristics of the second signal component, thereby enhancing the second signal component relative to a noise component in the filtered measured signal.

30. The system, as set forth in claim 29, wherein the first signal component is a pulsatile blood-related signal.

31. The system, as set forth in claim 29, wherein the second measured signal is ECG, the second signal component being representative of a QRS segment in the ECG signal.

32. A computer program storage device readable by a machine, tangibly embodying a program of instructions executable by a machine to perform method steps of processing a measured signal to extract a signal component and suppress a noise component of the measured signal, wherein the signal component is a substantially periodic signal characterized by a substantially well-defined peak-to-peak intensity value, which method comprises the steps of:

(i) determining upper and lower envelopes of the measured signal; and

(ii) analyzing the upper and lower envelope values to extract the signal component from the measured signal.

33. A computer program storage device readable by a machine, tangibly embodying a program of instructions executable by a machine to perform method steps of processing a measured signal to enhance a signal component relative to a noise component in the measured signal, wherein the signal component is characterized by a specific asymmetric shape, which method comprises the steps of:

- defining a kernel function being a derivative of a Gaussian with parameters matching the characteristics of the signal component; and

- applying filtering to the measured signal with the kernel function parameters, thereby enhancing the signal component relative to the noise component in the filtered measured signal.

34. A method for determining a parameter of a signal, comprising:

(i) determining upper and lower envelopes of the signal, and

(ii) analyzing the upper and lower envelopes to extract a signal component of the signal; and,

(iii) determining the parameter of the signal as a function of the signal component.

35. A method, as set for in claim 34, wherein the signal component is substantially periodic.

36. A method, as set forth in claim 34, wherein the signal component has a substantially defined peak-to-peak intensity value.

37. A method, as set forth in claim 34, wherein the step of analyzing the upper and lower envelopes includes the step of suppressing noise.

38. A method, as set forth in claim 34, including the steps of applying an external field to a sample and sensing the signal, wherein the signal is a response of the sample to the external field.

39. A method, as set forth in claim 34, including the steps of applying incident radiation to a sample and sensing the signal, where the signal is a response of the sample to the incident radiation.

40. A method, as set forth in claim 39, wherein the parameter of the signal corresponds to a physiological parameter of the sample.

41. A method, as set forth in claim 40, wherein the physiological parameter is pulsatile blood-related.

42. A method, as set forth in claim 40, wherein the physiological parameter is oxyhemoglobin saturation.

43. A method, as set forth in claim 34, wherein the step of analyzing the upper and lower envelopes to extract a signal component of the signal includes the step of determining a median of the difference between upper and lower envelope values.

44. A method, as set forth in claim 43, wherein the median is determined as an alternating value in the signal component.

45. A method, as set forth in claim 43, wherein the median is determined as a constant value in the signal component.

46. A method, as set forth in claim 34, wherein the step of analyzing the upper and lower envelopes to extract a signal component of the signal includes the steps of:

- determining a median difference between the upper and lower envelope values as an AC component of the signal component; and,
- determining a median of the upper envelope as a DC component of the signal component.

47. A method for determining a parameter of a signal having a signal component, including the steps of:

(i) defining a kernel function as a derivative of a Gaussian with parameters matching characteristics of the signal component; and

(ii) applying a spectral filter to the signal, the spectral filter using the kernel function and responsively enhancing the second signal component; and,

(iii) determining a second parameter of the signal as a function of the enhanced second signal component.

48. A method, as set forth in claim 47, wherein the characteristics of the signal component are a specific asymmetric shape.

49. A method for determining first and second parameters of a signal, the signal having first and second signal components, comprising:

(i) determining upper and lower envelopes of the signal, and

(ii) analyzing the upper and lower envelopes to extract the first signal component of the signal;

(iii) determining the first parameter of the signal as a function of the first signal component;

(iv) defining a kernel function as a derivative of a Gaussian with parameters matching characteristics of the second signal component; and

(v) applying a spectral filter to the signal, the spectral filter using the kernel function and responsively enhancing the second signal component; and,

(vi) determining a second parameter of the signal as a function of the enhanced second signal component.

50. An apparatus, comprising:

a detector for receiving a measured signal; and,

a controller coupled to the detector and adapted to receive the measured signal, determine upper and lower envelopes of the measured signal, analyze the upper and lower envelopes to extract a signal component of the signal, and to determine a parameter of the signal as a function of the signal component.

51. An apparatus, as set for in claim 50, wherein the signal component is substantially periodic.

52. An apparatus, as set forth in claim 50, wherein the signal component has a substantially defined peak-to-peak intensity value.

53. An apparatus, as set forth in claim 50, including an emitter to apply an external field to a sample, wherein the signal is a response of the sample to the external field.

54. An apparatus, as set forth in claim 53, wherein the parameter of the signal corresponds to a physiological parameter of the sample.

55. An apparatus, as set forth in claim 54, wherein the physiological parameter is pulsatile blood-related.

56. An apparatus, as set forth in claim 54, wherein the physiological parameter is oxyhemoglobin saturation.

57. An apparatus, as set forth in claim 50, wherein the controller is adapted to extract the signal component of the signal by determining a median of the difference between upper and lower envelope values.

58. An apparatus, as set forth in claim 57, wherein the median is an alternating value in the signal component.

59. An apparatus, as set forth in claim 57, wherein the median is a constant value in the signal component.

60. An apparatus, comprising:

a detector for receiving a measured signal; and,

a controller coupled to the detector and adapted to receive the measured signal, define a kernel function as a derivative of a Gaussian with parameters matching characteristics of the signal component, apply a spectral filter to the signal, the spectral filter using the kernel function and responsively enhance the second signal component, and to determine a second parameter of the signal as a function of the enhanced second signal component.

61. An apparatus, as set forth in claim 60, wherein the characteristics of the signal component are a specific asymmetric shape.